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THE ARKANSAS COAL MEASURES IN THEIR RELATION TO THE PACIFIC CARBONIFEROUS PROVINCE.[1]

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INTRODUCTION.

MARINE fossils of Coal Measure age were found by the Geological Survey of Arkansas in eighteen places, fourteen in the lower division and four in the upper. These localities extend from Independence county westward to Indian Territory, and give a total of 48 genera and 78 species, 31 species in the Lower Coal Measures, and 51 in the Upper, with 4 species common to both.

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[1] From an unpublished report of the Geological Survey of Arkansas, by permission of the Director, John C. Branner.

It is not thought that this small number of species represents the entire fauna, or that only four species are common to the two divisions, for the collections were much too scattered and too meager to exhaust the possibilities.

But the fauna is a poor one, such as one would expect to wander in from deeper waters, whenever a slight subsidence had made the shallow water a little more habitable. The fauna could not become well established, because the conditions soon reverted to their old state, and the inhabitants of the seas were forced to migrate or were exterminated.

There is, therefore, no gradual transition here from the fauna of the Lower Carboniferous limestone, since the presence of these fossils depends on the transgression of the sea on land areas, and the fossils of the Lower Coal Measures are just as different from those of the Lower Carboniferous as are those of the Upper Coal Measures.

No successful division of the Coal Measures into zones has ever been carried out, and in the present state of our knowledge it cannot be done. This makes the correlation of distant localities difficult, since the vertical range of species in the Coal Measures is very little known. Therefore, the range of the species in Arkansas cannot be given any closer than the two great divisions of the Coal Measures.

COMPARISON WITH THE PERMO-CARBONIFEROUS OF KANSAS AND NEBRASKA.

The fauna of the Upper Coal Measures of Arkansas has a strong resemblance to that of youngest Paleozoic beds of Kansas and Nebraska, described as Permian by Professor Geinitz.[1]

F. B. Meek redescribes this fauna,[2] and comes to the conclusion that the rocks in question are not to be referred to the Permian, because he can find no paleontologic or stratigraphic break to separate them from the Carboniferous. He finds 16 genera characteristic of the Carboniferous, and 7 genera not thought to antedate the Permian in Europe, but associated with genera not thought to occur later than the Carboniferous. Meek[1] says that *Fusulina*, which occurs in great numbers in the uppermost Carboniferous beds of Nebraska, is considered in Europe to be mainly if not exclusively a Lower Carboniferous genus. In this, however, he was mistaken; his opinion dates from a time when most geologists were inclined to place all Carboniferous limestone in the Lower Carboniferous. But it is now known that the Carboniferous limestone occurs in the Upper Carboniferous about as often as in the Lower, and the *Fusulina* limestones of Sicily and Russia grade over into beds of undoubted Permian age. This is also true of corresponding beds in the upper part of the Carboniferous of Texas. In fact the *Fusulina* beds are always either Upper Carboniferous or Permian, in eastern Europe and Asia, and nearly always in America.

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[1] "Carbonformation und Dyas in Nebraska."

[2] Final report U. S. Geol. Survey of Nebraska, etc., pp. 128 *et seq.*

Although undoubtedly believing in continuity of life and formations, Meek seems to have based his reasoning on the old idea of catastrophies, since he thought that the absence of a paleontologic or stratigraphic break was a sufficient reason for calling the beds in question Upper Coal Measures rather than Permian. A large majority of the genera and species are characteristic of the Carboniferous, and this Meek thinks sufficient to offset the fact that several genera previously considered typical of Permian[2] are present.

In the Upper Coal Measures of Arkansas out of 51 species, there are 25 in common with the doubtful strata of Nebraska, and 6 other species are common to the Nebraskan Permo-Carboniferous and the Lower Coal Measures of Arkansas, but have not yet been found in the Upper Coal Measures of the latter

[1] Page 33, op. cit.

[2] In the transactions of the Kansas Academy of Science, Vol. XIII., p. 38, Robert Hay announced that Professor H. S. Williams and Professor Tschernyschew had visited the Fort Riley section, and agree that it was undoubtedly Permian.

state. But of the genera mentioned by Meek as being considered not to antedate the Permian of Europe only two are found in the Arkansas strata, namely, *Synocladia*,[1] and *Lima*.

There is therefore not sufficient reason for classing the Poteau mountain beds with the Permian, but their fauna, as well as stratigraphic position place them very high in the Coal Measures, since they agree in fauna and position with the Mississippi valley Upper Coal Measures. These beds derive an additional interest from the fact that on Poteau mountain about one thousand feet of shales, in which no fossils were sought for, lie above the thin layer from which the entire collection was taken; thus the chances of finding true Permian beds in that region are very good.

RELATIONS TO THE TEXAS UPPER CARBONIFEROUS.

The only undoubted marine Permian in America has been described by Dr. C. A. White.[2] He finds the fauna of the upper Paleozoic beds of northern Texas, discovered by Professor W. F. Cummins, to be analogous to that of the *Fusulina* limestone of Sicily, the Artinsk stage of the Ural mountains, and the upper part of the *Productus* limestone of the Salt Range, India. These strata all show that peculiar commingling of ordinary Coal Measure fossils with ammonite genera, such as *Popanoceras*, *Medlicottia*, and *Waagenoceras*, which seems to be characteristic of open sea facies of the Permian.

None of the characteristic ammonite genera were found in the Arkansas region, but nearly all the fossils found in the Arkansas Coal Measures are also found in Texas. And in the Texas region nearly all the Permian species excepting the *Ammonites* were also found in the underlying Cisco division, which faunally and stratigraphically is the equivalent of the Upper Coal Measures of Arkansas.

Goniatites (*Gastrioceras*) *baylorensis* White is represented in

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[1] WAAGEN has shown, in Pal. Indica, Salt Range Fossils, I. Productus Limestone Fossils, p. 802, that *Synocladia* is not found in America, the species described by Swallow as *Synocladia biserialis* being a *Septopora*.

[2] Bulletin 77, U. S. Geological Survey.

Arkansas by the closely related species *Goniatites globulosus* Meek and Worthen.

Orthoceras rushense McChesney, is found in both areas; the *Endolobus* is possibly the same in both, or closely related; *Euomphalus subquadratus* Meek and Worthen, is common to both; *Bellerophon crassus* Meek and Worthen, is found in both areas; *Pleurophorus* sp. is probably the same in both regions.

Nearly all the Upper Carboniferous species of Texas and Arkansas are also found in Illinois, Iowa, etc., in beds that have never been thought to be other than Coal Measures. We are therefore safe in concluding, that while some of the beds in western Arkansas are very high up in the Coal Measures, none that belong above them are as yet certainly known, and the Poteau mountain syncline, across the line in Indian Territory, is the only place where there is any likelihood of finding Permian deposits.

COMPARISON WITH FOREIGN UPPER CARBONIFEROUS.

The Lo-ping fauna.—The descriptions of the fossils of the Lo-ping district of China, by Professor E. Kayser,[1] throw great light on the relations of the American Carboniferous faunas to those of Asia. Near Lo-ping, in eastern China, are found in strata overlying the coal-beds, numerous marine fossils of Upper Coal Measure age. Kayser has described 55 species, 10 not specifically identified, 15 cosmopolitan species, and 11 forms that are typically American, and belong chiefly to the Upper Coal Measures.

The 15 cosmopolitan species are also nearly all found in the American Upper Coal Measures, so that of the entire Lo-ping fauna nearly all the species are either found in America, or they have their nearest relatives there. The two regions belong to the same zoölogical province, the Pacific Carboniferous sea.

Many of these species that are very common in America and Asia are unknown or rare in Europe, which fact would tend to prove a connection with Asia by water, and the separation of the European and the American Upper Coal Measure deposits by a land barrier.

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[1] RICHTHOFEN: "China," Vol. IV.

The Carboniferous plants collected by Baron von Richthofen[1] numbered about 40 species and were nearly all identical with European Carboniferous plants. The natural inference is that in those times Asia was connected with Europe by land, and that the sea opened out to the east.

Professor J. S. Newberry[2] described a small collection of Carboniferous plants from China, and found nearly all of them to belong to well-known European species. This is in perfect agreement with the conclusions drawn above.

The Salt Range beds.—In the Salt Range, in northwest India, are found Upper Carboniferous deposits, some of which resemble those of Lo-ping, China; and the *Lower Productus* limestone of India is probably of about the same age as the beds of Lo-ping, and the western American Upper Coal Measures. These deposits and their fauna are described by Professor W. Waagen,[3] and in the volume on "Geological Results" he draws parallels between the faunas of the upper Paleozoic in different countries. Many of the American species that are found at Lo-ping are also found in the Salt Range *Lower Productus* limestone. This same type of Carboniferous is found in Sumatra, where it has been described by Ferd. Roemer,[4] and on Timor, where it was described by E. Beyrich.[5] This is the furthest southward that the Indian or northern type of Upper Carboniferous is known, and indeed the deposits of Sumatra and Timor begin to show already a greater affinity for the Australian or southern type of Carboniferous.

Waagen[6] divides the Carboniferous into two types, the northern or Asiatic, and the southern or Australo-African. The northern type is found in western Europe, Russia, the Himalayas, China, the Arctic regions and North America. The southern type is developed in South Africa and Australia, and extends into Peninsular India and Afghanistan. Brazil probably belongs to this type, but is to a certain extent transitional.

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[1] RICHTHOFEN: China, Vol. IV., Abhandlung 9, Dr. A. Schenk.

[2] American Journal of Science, Vol. 126, 1883, pp. 123 *et seq.*

[3] Paleontologia Indica. Salt Range Fossils.

[4] Paleontographica, Vol. 27, 1880.

[5] Abhandlungen der Berliner Akademie der Wissenschaften, 1864.

[6] Salt Range Fossils, Geological Results, p. 239.

The Itaitúba fauna.—A comparison of the Upper Carboniferous fauna of Itaitúba, Brazil, as described in part by Professor O. A. Derby,[1] shows that of 27 species of *Brachiopoda*, 12 are identical with American forms, although most of these are cosmopolitan. The genus *Strophalosia* is common in these beds, and as Professor Derby[2] says, the species shows affinity with the Permian. Many of the new species described by Professor Derby are closely related to the European forms. Waagen[3] says that the beds of Itaitúba are of the same age as the *Middle Productus* limestone of India, that is of the Permo-Carboniferous transition beds. The Brazilian *Strophalosia* is closely related to Australian species, indicating a closer connection with the Australian or southern Carboniferous region than with the Pacific province. Hence we infer that the Brazilian deposits may after all belong to the Upper Coal Measures, and that the difference between them and the northern Upper Coal Measures may be geographic instead of geologic.

CLASSIFICATION AND AGE OF THE ARKANSAS COAL MEASURES.

Provisional classification.—For the sake of convenience, the Coal Measures of Arkansas have been provisionally classified by the Survey as Upper or Productive, and Lower or Barren Coal Measures. This division is not based on any paleontologic or stratigraphic break, but merely on the occurrence or non-occurrence of coal.

The divisions that are recognized in Pennsylvania could not be recognized in Arkansas, but the strata of the two regions are correlated as far as possible with the scanty data now at hand.

The Lower Coal Measures.—Of the age of the Lower Coal Measures we have only stratigraphic evidence, their position above the limestone of the Lower Carboniferous, and below the coal-bearing beds of the Lower Coal Measures being unmistakable.

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[1] Bulletin Cornell University, Vol. I., No. 2.

[2] Op. cit., p. 60.

[3] Salt Range Fossils, "Geological Results," p. 207.

But their known fauna and flora have been too limited and too indecisive to enable us to correlate subdivisions with those of other Carboniferous areas, since collections have been made in but few places, and these chiefly in sandstones, where the preservation of fossils is usually unsatisfactory, and their determination uncertain.

But the Lower Coal Measures correspond in a general way to the Strawn and the Canyon divisions of Texas, the Pottsville conglomerate series, the Lower Productive Coal Measures, and part of the Lower Barren Coal Measures of Pennsylvania.

The Upper Coal Measures.—The Arkansas Upper Coal Measures correspond to the lower part of the Cisco of Texas, and belong just at the top of the true Carboniferous, and below the transitional Permo-Carboniferous or Artinsk stage, to which latter age the uppermost Cisco beds of Texas, with *Ammonites* (*Popanoceras*) *parkeri*[1] Heilprin belong. These may be the equivalents of the Poteau mountain marine beds.

The lower Permo-Carboniferous strata of Kansas and Nebraska are probably also to be correlated with the Artinsk[2] stage, although Waagen[3] classes the entire series with the ammonite-bearing beds of northern Texas, described by Dr. C. A. White in Bulletin 77 of the U. S. Geological Survey. The latter Texas beds, however, belong above the Artinsk stage, and in the true Permian, and are probably of the same age as the middle division of the *Middle Productus* limestone of the Salt Range.

Waagen, in "Salt Range Fossils, Geological Results," p. 238, gives a comparative table, showing the relationship of the upper Paleozoic strata all over the world. While the position assigned some of the American deposits does not agree with that accepted by most American geologists, still the table is useful for comparison, and it has been freely used in compiling the comparative table at the end of this paper.

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[1] This horizon is at the top of the Cisco, and above the horizon of *Goniatites marianus.*

[2] KARPINSKY: "Ammoneen der Artinsk-Stufe," p. 92.

[3] Salt Range Fossils, Geological Results, p. 204.

The beds of Poteau mountain, Indian Territory, are probably of the age of the Lo-ping strata of China, while the yellow shales of Scott county, Arkansas, Township 1 N., Range 28 W., Section 4, southeast quarter of southeast quarter, are probably of the age of the Upper Carboniferous limestone of Moscow, and the west slope of the Ural Mountains, if we can judge by the occurrence of *Gastrioceras marianum* and *Pronorites* in them. This would make them older than the Poteau mountain shales, which is very likely the case.

Paleobotanic evidence.—Our knowledge of the paleobotany of the Coal Measures of Arkansas has been up to the present time very limited, depending almost entirely on the publications of Lesquereux, in the "Second Annual Report of a Geological Reconnaissance of the Middle and Southern Counties of Arkansas," 1860, and in the Second Geological Survey of Pennsylvania, Report of Progress, P, "Description of the Coal Flora of the Carboniferous Formation in Pennsylvania, and throughout the United States," 1884.

The joint monograph of H. L. Fairchild and David White, on the "Fossil Flora of the Coal Measures of Arkansas,"[1] throws much new light on the stratigraphic and regional distribution of species, and has been of material aid in correlating the Arkansas strata with those of other regions. They prove that all the Coal Measure plants[2] published from Arkansas belong to the horizon of the Upper or Productive Coal Measures.

The Van Buren plant bed is thought, from paleobotanic evidence, to belong above the horizon from which most of the coal of Arkansas is obtained, that of the Ouita coal, and this agrees with the evidence given by the stratigraphy and the marine fossils. The Van Buren plant bed occurs below the Poteau mountain marine beds, and above those in Sebastian county, Township 8 N., Range 32 W., Section 12; and these latter marine beds occur above the horizon of the Ouita coal.

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[1] An unpublished report of the Geological Survey of Arkansas.

[2] The work of the Survey shows that the plants described by Lesquereux from Washington county as Sub-Conglomerate belong to the Lower Carboniferous.

The Poteau mountain marine beds are of about the same age as the Wyoming valley limestones[1] of the Upper Productive Coal Measures of Pennsylvania, and these belong below the Dunkard creek series of the Upper Barren Coal Measures. The Dunkard creek[2] beds have lately been proved by Professor I. C. White to be of the same age as the Permian of northern Texas, on the basis of plant remains that also occur towards the top of the Wichita series of Texas, in which marine Permian fossils[3] have already been found.

But the paleobotanic evidence aids in establishing the age of the Upper Coal Measures only; plants are not reported from any horizons of the Lower Coal Measures, although they are known from a few localities.

Owen[4] mentions *Stigmaria ficoides* as occurring at Patterson's mill, near Bee Rock, on Little Red river, White county. In August, 1892, a few plants were found by the Survey in the Bee Rock sandstone, near the base of the series and below most of the marine fossils, but none of these could be identified.

General D. McRae, of Searcy, informed the Survey that in Township 7 N., Range 7 W., Section 4, in White county, were found shales containing numerous *Lepidodendra* and ferns. These shales are above the Bee Rock sandstones.

In a well at Dr. Griffin's, Township 5 N., Range 10 W., Section 5, near El Paso, White county, specimens of *Lepidodendron* were collected by Dr. J. C. Branner, in micaceous flaggy sandstone, thought to be of the same age as the shales of Searcy. About fifty feet above the flaggy sandstone was found a thin bed of coal, and thirty feet higher was another coal bed with numerous ferns and *Calamites* in the overlying shales.

C. S. Prosser[5] mentions plants supposed to be of Lower

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[1] Second Geol. Sur. of Pa., An. Rep., 1885, pp. 437–458, C. A. ASHBURNER and A. HEILPRIN, "Report on the Wyoming Valley Limestone Beds."

[2] Bul. Geol. Soc. America, Vol. III., p. 217.

[3] Dr. C. A. White, Bulletin 77, U. S. Geological Survey.

[4] Second Geol. Recon. Ark., Vol. I., p. 68.

[5] Ark. Geol. Survey, An. Rep., Vol. III., 1890, p. 423.

Carboniferous age, from Shinall mountain. In quarries in the sandstones of Big Rock, near the city of Little Rock, are found plant remains of indeterminable character. The stratigraphy of the Survey places both localities in the Lower Coal Measures, and probably above the fossiliferous sandstones of Bee Rock, on Little Red river.

THE PACIFIC CARBONIFEROUS SEA.

Revolution in Devonian time.—In Paleozoic times there have been many revolutions and alternations of continents and seas, and consequent readjustment of their inhabitants to new surroundings. One of the greatest of these was that which broke up a large zoölogical province, and put in direct connection regions that before were separated.

Dr. A. Ulrich[1] has shown that in lower and middle Devonian the faunas of Bolivia, Brazil, the Falkland Islands, and South Africa were very similar to those of North America, and that they were very different from the faunas of Europe and Asia. This state lasted until the end of the middle Devonian, when the revolution began. Professor H. S. Williams[2] has shown that with the beginning of the upper Devonian in America there came in a fauna, many species of which were not the direct descendants of those immediately preceding them. This new fauna was, however, closely related to forms known in Europe and Asia, but unlike those of the southern regions.

Professor Williams[3] afterwards elaborated this theory, and followed out closely the changes that were inaugurated towards the end of the Devonian. The culmination of these changes produced the Pacific Carboniferous sea.

The Carboniferous sea.—From chapter V., in Suess' "Antlitz der Erde," Vol. II., we get many valuable suggestions as to the outlines of the Pacific Carboniferous ocean. The Subcarboniferous was the time of greatest transgression of sea over the present land areas, while the sea in which the *Fusulina* beds of Europe and America were formed was more circumscribed.

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[1] Beiträge zur Geologie und Paläontologie von Südamerika, I., "Paläozoische Versteinerungen aus Bolivien."

[2] Bull. Geol. Soc. America, Vol. I., "The Cuboides Zone and Its Fauna.

[3] Proc. Amer. Assoc. Adv. Sc., 1892, Section E, Address, "The Scope of Paleontology and Its Value to Geologists."

The Waverly group when traced towards the west gradually takes on the character of deep water formations ; it is persistent through Nevada and California,[1] and is known, from unpublished investigations, to have a similar fauna in these two states. The Waverly probably persisted much longer in the west, than in the east, for in northern Missouri C. R. Keyes[2] has observed that in the midst of an undoubted Burlington fauna a well marked Kinderhook or Waverly fauna reappears. This he explains by Barrande's theory of colonies. It is probably an incursion of the inhabitants of a deeper western sea, where the Waverly had persisted longer, into the shallower eastern waters. The work of the Geological Survey of Arkansas shows that a similar phenomenon occurs in that state. The Fayetteville shale, which is probably of Keokuk age, contains a fauna that differs markedly from those of the limestones above and below it. An unpublished report by Professor Henry S. Williams shows the occurrence in the Fayetteville shale of several species that occur in a doubtful upper Devonian or lower Carboniferous black shale in the White Pine district, Nevada. Along with these Devonian or Waverly species occur others that belong much higher, as *Productus semireticulatus*, and *Goniatites* conf. *sphæricus*. Below the Fayetteville shale is the Boone chert, which at the base contains a decided Burlington fauna, and at the top probably belongs to the Keokuk. This has been observed in so many places that there is no possibility of mistake in the sequence of the strata.

We have therefore in Arkansas an incursion similar to that in Missouri, except that in Arkansas the incursion came considerably later. This is evidence that somewhere in the west the Waverly fauna persisted throughout the Burlington, and at least a part of the Keokuk. This is in accordance with the phenomenon described by Professor C. D. Walcott in Monograph VIII.,

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[1] Zoe, Vol. III., p. 274 ; Proc. Calif. Acad. Sci., Oct. 17, 1892.

[2] American Journal of Science, December, 1892, p. 447.

U. S. Geological Survey, from the Eureka district, Nevada, where a Waverly fauna occurs 3000 feet above the base of the Carboniferous formation. The same thing has been observed by the writer in the Carboniferous of Shasta county, California.

The Lower Carboniferous limestones can be traced all through the west and the Mississippi Valley, to the base of the Appalachian Mountains, where they are replaced by conglomerates and other coarse sediments.

Upper Carboniferous in the West.—Of the Upper Carboniferous all that we know west of Indian Territory takes on a decidedly marine character, containing thick beds of limestones.

There are however some thin beds of coal in Texas, and some carbonaceous seams with a few land plants in New Mexico and Nevada. The coal in Texas was probably deposited near the southern shore line of the Carboniferous sea, and the carbonaceous seams in the far west probably belong to insular areas.

The fossils described from the Western Carboniferous are all marine, with the slight exception that Walcott[1] mentions a few specimens of pulmonate *Gasteropoda*, that were found along with brachiopods, corals, and land plants, evidently washed in from a distance, since no terrestrial Carboniferous deposits are known near the Eureka district.

The Pawhuski limestone.—In the eastern part of Indian Territory are found large deposits of coal in the Upper Coal Measures, but further west the same horizon is represented by marine limestone. In 1892 Mr. H. C. Hoover, of the Geological Survey of Arkansas, found at the government lime-kiln, three miles northwest of Pawhuski, Oklahoma Territory, Osage Agency, a bed of massive limestone about 100 feet thick, lying horizontally on heavily bedded sandstones. The limestone is fossiliferous, but the sandstones are not. The fossils collected were placed at my disposal, and on examination they proved to be:

Spirifer cameratus Morton.

Athyris subtilita Hall sp.

Productus semireticulatus Martin sp.

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[1] Mon. VIII., U. S. Geol. Survey, p. 262.

Productus nebrascensis Owen.

Productus longispinus Sowerby.

Streptorhynchus crassus Meek and Hayden.

These are plainly of Upper Carboniferous age. The limestones cap the hills in that region, and spread over a great area, but fossils were collected at this place only.

Interchange of life between East and West.—The many beds of marine fossils in the Productive Coal Measures are simply transgressions from the western sea, and reach no further east than Pennsylvania and West Virginia. The Appalachian system was the western border of the ancient Atlantis[1] which separated the European from the Pacific waters, while the great Indo-Australian[2] continent bounded the Pacific ocean on the south. This ocean must have stretched from the American Coal Measures to eastern China, the Salt Range in India, the Ural Mountains on the borders of Russia, and into the Arctic regions, for we find related faunas in all these places. Whatever we have of western European Coal Measure species must have migrated from this direction, since on the east there was no direct communication with European waters. An example of this is *Productus giganteus*[3] Martin, which is common in Europe, and is found in the Lower Carboniferous of the McCloud river, Shasta county, but is not found east of that place, unless *P. latissimus* Sowerby, from Montana, west of the main chain of the Rocky Mountains, be an equivalent.

On the other hand, many species seem to be confined to, or characteristic of, this ocean; among them may be mentioned *Productus cora* d' Orbigny, which Waagen[4] says is not found in Europe, its nearest representative being *Productus riparius* Trautschold; it was however first described from South America.

Goniatites marianus Verneul is found in the Artinsk region of the Urals, probably in Sumatra, and in Arkansas. The genus *Pronorites*, while found in western Europe, is rare in it, and is much more common in the Pacific region. *Pronorites* is found in the Artinsk region and in Arkansas, while the ammonite genus *Medlicottia*, the direct descendant of *Pronorites*, is found in the Permo-Carboniferous strata of Sicily, the Urals, the Salt Range, and Texas.

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[1] SUESS: Antlitz der Erde, II., p. 17.

[2] SUESS: Antlitz der Erde, II., p. 316.

[3] See Annual Report U. S. Geog. and Geol. Surv. Terr. 1883, Part I., p. 132, and Bull. Geog. and Geol. Surv. Terr. Vol. II., No. 4, p. 354.

[4] Pal. Indica, Salt Range Fossils, Brachiopoda, p. 677.

It is impossible to suppose that the same genus and species originated at different localities, and since we have both ancestors and descendants in places so widely separated, we can only suppose that there was free interchange of life between those places at that time, or in other words an open sea, on the borders of which these fossiliferous deposits were laid down, and through which the cephalopods and other marine animals could migrate.

Replacement of Limestones by coal-bearing formations in western Europe.—On tracing the Upper Carboniferous deposits of the Ural region towards the west, we find the limestones thinning out, and the Coal Measures and Culm formations taking their places; we find also that the transgression of marine on terrestrial deposits takes place from the east, just the reverse of what is seen in America.

Land areas in the West.—It is not thought that the Pacific Carboniferous sea was an unbroken expanse of water in western America; on the contrary there are many evidences of large isolated land areas and archipelagos.

Dr. Joseph Le Conte[1] has argued that the Basin Range, during much of Paleozoic and Mesozoic time, was a continent, off the western shores of which the sediments that afterwards became the Sierra Nevada and Coast Range were laid down. Clarence King[2] thought that the great thickness of Paleozoic littoral deposits in the Great Basin region proved the existence of a large body of land further west; he thought that the eastern shore of this continent was in Nevada, and east of this stretched the Carboniferous sea, which covered all but the island chain of the Rocky mountain region. King[1] further concluded that the Carboniferous in California, west of the old shore line, indicated shallow bays that permitted the western extension of the upper Paleozoic deposits, while the bulk of them was stopped by the bold coast. There are evidences of land areas in the Rocky mountains, Wahsatch mountains, New Mexico, and Nevada, but from the facts now known it seems more probable that these were large islands or archipelagos, rather than continents.

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[1] American Journal of Science, III., Vol. 16, p. 108.

[2] U. S. Geol. Explor. Fortieth Parallel, Vol. I., p. 534.

THE PERMIAN PACIFIC OCEAN.

The outlines of the great western ocean can be traced in Permian times also, but with much more circumscribed limits. Open sea deposits of this age are known in Texas, in the Salt Range, on the west slope of the Urals, on the island of Sicily, and in scattering places in central Asia. In all these the genera are nearly the same, except that the *Arcestes* types are confined to the more southern regions. This similarity indicates plainly a connection of these deposits.

Suess[2] argues that the open sea Permian fauna wandered in from the south, and that the Mesozoic types of *Ammonites* were foreign to the northern regions.

Karpinsky,[3] on the contrary, holds that they were autochthonous, at least in the Ural region, since he could trace the descent of all the *Ammonites*, except the *Popanocerata* from *Goniatites* that were found in the underlying Carboniferous.

As has been already mentioned, the ammonite genus *Medlicottia* is not a foreigner on this side of the Permian Pacific ocean, because its ancestor, *Pronorites*, is found here too.

The Triassic Pacific ocean.—Our knowledge of the Triassic Pacific ocean is based on the work of Mojsisovics, "Arktische Triasfaunen."[4] We find that in this period the American part of the great western ocean has mostly become land, and only on the western border of America do we find marine Triassic beds, in Nevada, California, Idaho, and along the Coast region in scattering places from Alaska to Peru.

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[1] Op. cit., p. 535.

[2] Antlitz der Erde, II., p. 316.

[3] Ammoneen der Artinsk-Stufe, p. 86.

[4] Mem. Acad. Imper. Sci. St. Petersbourg, Tome 33, No. 6.

These deposits, with similar fauna, can be traced on the other side of the Pacific, from New Zealand, Timor, New Caledonia, to Japan and Siberia. This sea stretches out on one side over the Himalayas to the eastern Alps, forming what Neumayr[1] calls the "central mediterranean sea." On the south side the sea stretched up to Spitzbergen, but did not reach the Atlantic region. The Triassic was a continental period for the greater part of the present continents.[2]

After the Trias the outlines of the western ocean had changed entirely, and no resemblance to the original boundaries can be traced.

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[1] Denkschrift Wiener Akad., 1885, "Die Geographische Verbreitung der Juraformtion."

[2] SUESS: Antlitz der Erde, II., p. 147.

CORRELATION TABLE OF THE COAL MEASURES OF ARKANSAS WITH THE PACIFIC CARBONIFEROUS PROVINCE

		Arkansas.	Indian Territory	Texas	Mississippi Valley	Pennsylvania	China and other parts of Asia	Russia and Ural Mts.	India	South America
PERMIAN			Permo-Carboniferous	Wichita Series, with *Medlicottia, Popanoceras Waageno-ceras*, etc. *Popanoceras parkeri* Beds	Permo-Carboniferous of Kansas and Nebraska	Upper Barren Coal-Measures	Bokhara Cephalopod Beds	Kostroma Permian Artinsk Stage	Productus Speck. Sand-stone Series Productus Lime-stones	Itaitúba Beds
COAL-MEASURES OR PENN-SYLVANIAN	UPPER COAL-MEASURES	Poteau Mountain Marine Beds.............. Van Buren Plant Beds..................... Fort Smith Marine Beds.................... Ouita Coal Horizon with Plants............. Boles, Scott County, Beds with *Goniatites marianus and Pronorites*............	Productive Coal-Measures Pawhuski Limestone	Cisco	Upper Coal-Measures	Upp. Prod. CoalMeas. Wyoming Valley Lime-stones Lower Barren Coal-Meas.	Marine Beds of Lo-ping Productive Coal-Measures of China	North. Russ. NovaZembla Upper Carboniferous Limestone	Spiti Limestones	Plant Beds
	LOWER COAL-MEASURES	Morrillton Marine Beds........................ Conway County Millstone Grit, with Marine Fossils .... Big Rock, Pulaski County, Plant Beds...... El Paso, White County, Plant Beds......... Searcy, Bee Rock, Marine Beds............ Searcy, Bee Rock, Plant Beds		Strawn and Canyon Divisions	Lower Coal-Measures	Lower Produc-tive Coal-Meas. Pottsville Conglomerate		Middle Carbon-iferous Lime-stone	Muth Quartz-ites Lime-Stones	
LOWER CAR-BONIFEROUS OR MISSISSIP-PIAN		Lower Carboniferous Limestone.............	Lower Carboniferous Limestone	Bend Division	Lower Carbonifer-ous Limestone	Mauch Chunk Series	Lower Carbonifer-ous Limestone	Lower Carbonifer-ous Limestone	Crinoidal	